LLNL Environmental Restoration Division Standard Operating Procedure	TITLE: Well Closures
APPROVAL Date _____ _____ Livermore Site Deputy Program Leader	PREPARERS: B. Qualheim and M. Taffet REVIEWERS: R. Bainer, L. Berg*, T. Carlsen, V. Dibley J. Gardner*, J. Greci, and J. Hoffman*
APPROVAL Date _____ _____ Division Leader CONCURRENCE Date _____ _____ QA Implementation Coordinator	PROCEDURE NUMBER: ERD SOP-1.7 REVISION: 2 EFFECTIVE DATE: December 1, 1995 Page 1 of 8

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1.0 PURPOSE

This procedure describes methods for decommissioning wells *in situ* or by removal. The well closure technique is commonly dependent on the well material. *In-situ* well closures involve casing perforation and are used when metal casing cannot be easily removed. Well closures by removal are used for any well material if it is practical to drill the well out using hollow stem augers. If a well cannot be removed by hollow stem augers, the well can be drilled out with a drill bit. This method is primarily used for wells constructed completely of polyvinyl chloride. The Drilling Supervisor (DS) will determine if a combination of closure methods is required for wells with one or more conductor casings. Local regulatory agencies will be consulted if, for any reason, a well cannot be decommissioned solely by the methods discussed below.

2.0 APPLICABILITY

This procedure is applicable to wells that are to be permanently sealed, based on the present or future potential of a well to act as a conduit for vertical migration of hazardous materials. A well meeting the criteria listed below should be considered for closure:

A. Multiple screened intervals or single screened intervals over several water-bearing zones.

B. Lack of annular seal.

C. Any well suspected of allowing migration of contaminants to noncontaminated zones.

D. Threatened water supply wells located at or near an existing plume margin.

E. Unknown or undocumented well construction details.

F. Improper well construction or damaged wells.

G. Abandoned wells (DWR, 1981).

3.0 REFERENCES

3.1 Department of Water Resources (1981), *Water Well Standards: State of California,* California Resources Agency, Bulletin 74-81.

4.0 DEFINITIONS

Not applicable.

5.0 RESPONSIBILITIES

Note: The following responsibilities (Sections 5.1–5.5) are listed by the appropriate level of authority to ensure that proper representation for all procedures and regulations related to this SOP are met.

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeologic Group Leader (HGL)

The HGL's responsibility is to ensure that proper procedures are followed for activities (i.e., drilling, borehole logging and sampling, monitor well installations and development) and to oversee the disposal of all investigation derived wastes.

5.3 Drilling Supervisor (DS)

The DS plans and coordinates all drilling related activities, ensures that all drilling related activities are performed safely and efficiently (using the proper procedures), and that the data generated from these activities are valuable and representative of the true geologic or physical conditions within the borehole. Such activities may include operation of logging equipment, soil sampling, well installation, and development. The DS is also responsible for:

5.3.1 Coordination of the drilling contractor schedules and equipment needs:

- Coordinate the schedules of multiple drill rigs with the drilling contractor.
- Provide the Work Plan to the drilling contractor and answer questions.
- Negotiate the arrival/start date and drill type.
- Monitor the progress of the drilling and anticipate changes in equipment needs (e.g., auger rig, air-mist rig, mud-rotary rig).

5.4 Drilling Coordinator (DC)

5.4.1 The DC provides the interface between the DS and the field activities including:

- Oversight of the Drilling Geologist (DG) and field activities.
- Coordinate the DG's work load.
- Obtain the necessary equipment, supplies, and release numbers from the Technical Release Representative (TRR) for the drilling contractor.
- Provide guidance and training.
- Inform the DG about procedural changes in areas related to drilling (e.g., changes in sampling requests, cuttings disposal issues, new forms, etc.).
- Provide technical input to the DG and Study Area Leader (SAL)/Facility Task Leader (FTL).
- Review borehole and geophysical logs.
- Monitor drilling progress on a daily basis.
- Interact with the Quality Assurance (QA)/Quality Control (QC) officer on drilling and soil sampling issues.
- Estimate the contaminants likely to be present, and the quantity of drilling spoils that may be generated.

5.4.2 During the startup of a new drilling phase, the DS works with the DC and SAL/FTL to:

- Create and finalize all related drilling documents (i.e., the Work Plan and Sampling Plan).
- Work with the SAL/FTL to establish drilling locations, schedules, and budgets for each well.
- Determine the protective equipment necessary for personnel in the field.
- Make well completion decisions and specify the well construction details from the SAL/FTL and HGL input.
- Act as the liaison between the SAL/FTL and the DG.
- Coordinates all necessary biological/archeological surveys prior to drilling. Results of the surveys should be forwarded to the SAL/FTL and Environmental Chemistry and Biological Group Leader (ECBGL).

5.5 Drilling Geologist (DG)

The DG's responsibility is to ensure that drilling activities are carried out according to the specifications designated in the Work Plan, Sampling Plan, Site Safety Plan (SSP), Operation Safety Procedure (OSP), and Standard Operating Procedure (SOP). Additionally, the DG must oversee and document all aspects of the drilling/field investigation, including lithologic and geophysical data, well completion and development specifications, activities of the drillers, sampling and workspace monitoring details. The DG is also responsible for:

5.5.1 Site Preparation and Supply Ordering. The DG must:

- Review the Work Plan prepared by the SAL/FTL and DC, and discuss any questions.
- Assemble all necessary materials, including personal protective equipment (PPE).
- Supply tracking and ordering requests.
- Confirm that all necessary security arrangements have been made to permit site access (e.g., schedule escorts, notify the building coordinator of planned activities, arrange for opening of locked gates).
- Confirm that utility locator and mud pit excavations (if necessary) have been arranged with the field personnel.
- Discuss LLNL site planning requirements and utility lines with field personnel and drillers before drilling begins.

5.5.2 Site Safety

- Supply the SSP, OSP, and SOPs to all workers who enter the drill site.
- Monitor and record work space conditions with appropriate monitoring equipment (including FID, PID, etc.) during drilling activity.
- Confirm that appropriate fencing, warning signs, barricades, animal exit ramps (for mud pit), borehole cover and protection are in place.
- Discontinue work and contact the DC if chemical or physical hazards are encountered.

5.5.3 Field Activities

- Coordinate schedules/actions with field personnel.
- Research site hydrogeology to estimate key parameters (e.g., sample target zones, hydrostratigraphic unit depths and thicknesses, and types of contaminants).
- Obtain a field logbook from the Data Management Group (DMG).
- Calibrate and record calibration information for all monitoring equipment.
- Confirm all sample naming conventions with DMG.
- Collect and document samples.
- Handle all changes and corrections to chain-of-custody (CoC) forms and/or analytical requests.
- Inform the DC, SAL/FTLs, and DMG of any sampling or sampling documentation irregularities.
- Report any deviations from the SSPs, OSPs, or SOPs to the QA/QC Officer.
- If SOPs are violated, a nonconformance report is to be completed and submitted to the QA/QC officer.
- Report missed turnaround times for analytical sample results to QA/QC Officer.
- Confirm that drilling waste analytical results are consistent with the chosen disposal method.

- Decontaminate all sampling equipment.
- Provide frequent updates and documentation of field activities to the DC, HGL, and SAL/FTL.

5.6 Environmental Chemistry and Biology Group Leader (ECBGL)

The ECBGL's responsibility is to provide biological or chemical information and expertise (i.e., biological surveys, water supplies, chemical field instruments, etc.).

5.7 Field Personnel

The field personnel's responsibilities are to conduct all ERD field work that complies with all established operational and safety procedures, and to inform the HGL when the procedures are inappropriate.

Activities the field personnel are responsible to perform (but are not limited to) are to:

- Collect, store, and ship borehole samples to analytical laboratories.
- Drill, complete wells, log boreholes, and properly develop wells to allow the highest yield and the highest quality samples.
- Communicate the performance of development activities to the HGL and DC to allow for modification of the development methods to improve well yield.

5.8 Site Safety Officer (SSO)

The SSO's responsibility is to ensure the safety of ERD's ongoing operations and facilities and work performed. The SSO's responsibility is to receive the details of potential hazards and procedures for all field activities. The SSO directs this information to the LLNL Hazards Control Department to determine if a new Operational Safety Procedure (OSP) is required, thus assuring that an existing OSP addresses all ES&H issues for each operation.

5.9 Study Area Leaders (SAL)/Facility Task Leader (FTL)

The SAL/FTL are responsible for the overall investigation, planning, assessment, and remediation within a study area.

5.10 Technical Release Representative (TRR)

The TRR is responsible for the acquisition and administration of blanket contract releases for the procurement of goods and services. The TRR has the authority to obligate LLNL for payment of goods and services, delegated by the LLNL Business Manager through the LLNL Procurement Department.

5.11 Treatment Facility Hydrogeologist (TFH)

The TFH is responsible for helping the SAL/FTL determine borehole location and target zone for completion.

6.0 PROCEDURES

6.1 Office Preparation

6.1.1 *In-Situ* Closure

A. Obtain all pertinent records such as drillers' logs, water level measurements, perforated intervals, and any required permits or access agreements.

B. Obtain necessary permits for off-site wells.

C. Obtain Mills Knife perforation equipment and air compressor, making sure the correct shoes are available for each casing diameter.

D. Determine the depth intervals of clay-rich zones greater than 5-ft thick from geophysical logs (gamma ray), drillers' logs, or other well logs.

E. Determine zones to perforate from evaluation of logs, taking into account the zones that had been perforated previously.

F. Determine or estimate the depth of any nearby ground water contaminant plumes for each well location.

G. Review associated SOPs and pertinent sections of the Site Safety Plan (SSP).

H. Coordinate schedule/actions with DC.

6.1.2 Well Removal

A. Obtain all pertinent records such as drillers' logs, water-level measurements, perforated intervals, and any required permits or access agreements. Conduct a downhole camera survey if additional information is necessary.

B. Review associated SOPs and pertinent sections of the SSP.

C. Coordinate schedule/actions with DC.

6.2 Field Preparation

6.2.1 Remove pump and piping from the well.

6.2.2 Determine that there are no obstructions in the well. For deep wells, run video logs and geophysical logs as needed to ascertain casing condition, presence and openness of existing perforations, and location of high and low permeability intervals.

6.2.3 Check drill rig access to the well.

6.2.4 Remove existing vault or stove pipe and concrete pad, if necessary.

6.2.5 Follow the instructions pertaining to conducting field work per SOP 4.1, "General Instructions for Field Personnel."

6.3 Operation

6.3.1 Document the following for all wells**:**

A. Well name.

B. Sounded depth of well.

C. Water level, if applicable.

D. Casing size and materials.

E. Drilling company and driller.

F. Drilling Supervisor and Drilling Geologist.

G. Date/time start and complete closure.

H. Closure method(s) and materials used.

I. If no survey data exists, prepare a detailed site map accurately showing the well in relation to permanent features.

6.3.2. *In-Situ* Closure

A. Select intervals to perforate from the drillers' log, geophysical log, and video log if available. Determine if previously perforated zones should be reperforated due to possible compromise of casing.

B. Operate Mills Knife perforator to cut six 1-in. slots per foot, with four rows at 90 degrees from one another.

C. Perforate all previously unperforated low-permeability zones greater than 5-ft thick within the plume, and selected low-permeability zones greater than 5-ft thick between the static water level to 20 ft below the estimated base of plume.

D. If casing conditions permit, perforate all low-permeability zones (thicker than 5 ft) that occur between the estimated plume base and total depth.

E. Calculate the minimum volume of grout required to seal the well.

F. Pump the grout from the bottom of the well to the surface through a tremie pipe using a cement mixture (2 lb of commercial bentonite powder and approximately 6.5 gal of water added per 94-lb bag of cement).

G. When the grout reaches the surface, verify that the volume of grout used is equal or greater than the calculated volume in Step E.

H. Apply pressure from the surface using either an air-actuated packer or a welded cap at the surface. Apply at least 50 psi of pressure for approximately 1 to 2 hr until stable.

I. The following day, seal the surface by perforating a zone from 2 to 20 ft, and top off to the surface with a final stage of grout.

6.3.3 Well Removal

A. Drill out the casing using hollow stem augers or a drill bit, as determined by the driller. For both methods, the drill bit should be slightly larger than the diameter of the original well borehole to remove all of the filter pack.

B. To the extent feasible, ensure that all of the casing has been removed. When using a drill bit, frequently check and document that pieces of casing are in the cuttings. Also note any decrease in drill rig chattering, which may indicate that the bit has deflected off the casing.

C. Once the well and sandpack are completely removed, an open borehole remains. Calculate the minimum volume of grout required to fill the open borehole.

D. Pump the grout from the bottom of the borehole to the surface through a tremie pipe (grouting with a tremie pipe is not required for dry boreholes that do not exceed 30-ft depth). Place the tremie pipe 5 to 10 ft off the bottom of the borehole and pump a cement mixture (2 lb of commercial bentonite powder mixed with approximately 6.5 gal of water per 94-lb bag of cement) through this pipe until undiluted grout flows from the borehole at the ground surface. The tremie pipe should be withdrawn gradually during this process.

E. When the grout reaches the surface, verify that the volume of grout used is equal or greater than the calculated volume in Step C.

F. While waiting for the grout to set, cover and barricade the borehole to prevent introduction of foreign material and to protect the public.

G. After the grout has set (about 72 hr), fill any depression in the grout due to settlement. Use a grout mixture similar to that described above.

6.4 Field Post Operation

Decontaminate all equipment as noted in SOP 4.5, "General Equipment Decontamination."

6.5 Office Post Operation

Give original field forms to Data Management Group for filing and distribution.

7.0 QUALITY ASSURANCE RECORDS

7.1 Field Forms

7.2 Logbooks

8.0 ATTACHMENTS

Not applicable.